Updated Expert Report of Robert Moran

January 2008

Robert Moran

Updated Expert Report of Robert Moran

January 2008

Robert Moran

Qualifications

I am a specialist in water quality, hydrogeology and geochemistry, and a partner in Michael Moran and Associates, LLC. I hold a Bachelor of Arts degree in Zoology from San Francisco State College and a PhD in Geological Sciences from University of Texas.

I have more than thirty-five years of domestic and international experience in conducting and managing water quality, geochemical and hydrogeologic work for private investors, industrial clients, tribal and citizens groups, non-governmental organizations (NGOs), law firms, and governmental agencies at all levels. Much of my technical expertise involves the quality and geochemistry of natural and contaminated waters and sediments as related to mining, nuclear fuel cycle sites, industrial development, geothermal resources, hazardous wastes, and water supply development. In addition, I have significant experience in the application of remote sensing to natural resource issues, development of resource policy, and litigation support.

I have taught courses to technical and general audiences, and have given expert testimony on numerous occasions. I have worked on projects in numerous countries, including: Australia, Greece, Mali, Senegal, Guinea, Gambia, Ghana, South Africa, Iraqi Kurdistan, Oman, Pakistan, Kazakhstan, Kyrgyzstan, Mongolia, Romania, Russia (Buryatia), Argentina, Chile, El Salvador, Guatemala, Honduras, Mexico, Peru, Canada, Great Britain, and the United States.

Among recent international work, I reviewed the environmental impact assessment on water and other environmental issues, and the permit conditions, at the proposed Esquel mine in northern Patagonia, Argentina and at the Marlin Mine in Guatemala. In Southern Mali I reviewed the environmental conditions and documents related to an IFC-funded gold mine. I reviewed water and environmental issues at the San Andres mine in Honduras. In Peru I reviewed mining water and environmental issues, which included numerous public presentations to citizens and governmental groups, including members of the Peruvian Congress. In Greece I gave technical assistance to an advisory arm of the Greek government and citizens groups regarding gold mining and environmental issues. In Australia I reviewed water quality issues related to cyanide leach gold operations on aboriginal lands and gave testimony at the Land and Environment Court. I evaluated environmental costs associated with copper mining in Chile. In South Africa I taught cyanide technology and environmental assessment issues at a United Nations-sponsored course. In Kyrgyzstan I gave water quality instruction to regulators and NGOs regarding mining, sampling, laboratory procedures, and general environmental issues, and reviewed a local laboratory.

I have prepared geochemical and hydrogeology studies and monitored water quality at mining sites across the United States. For instance, I have given litigation support on water quality, geochemistry, and treatment issues to groups opposed to a proposed gold operation at the Crown Jewel Mine in Washington. I assumed technical and management responsibilities for water resources and geochemistry tasks in preparation of an Environmental Impact Statement (EIS) at a gold-cyanide leach site with existing acid drainage problems for Zortman Mining Co. and the U.S. Bureau of Land Management. I was responsible for geochemistry and water quality aspects of a supplemental EIS at a new gold mine site for Echo Bay Mining. I have overseen water quality sampling, and evaluated water quality and remote sensing activities related to major water

development litigation in the San Luis Valley, Colorado. I acted as a geochemical/water quality consultant at the Beartrack mine site, a proposed cyanide-leach gold project in Idaho. I evaluated existing surface and groundwater quality data and suggested remedial activities to deal with excessive manganese and dissolved organic concentrations and provided testimony to the Brighton City Council in Colorado.

I have worked for groups as diverse as the U.S. Environmental Protection Agency, Kennecott Utah Copper, Oxfam America, Greenpeace Argentina, Asociation de Organismos No Gubernamentales, Nacho Nyak Dun First Nation, Dogrib Nation, Soros Foundation Kyrgyzstan, Mineral Policy Center, World Resources Institute, U.S. Bureau of Land Management, U.S. Forest Service, Molycorp/Unocal, Southern Peru Copper Corp., Zortman Mining Co., Chino Mines, Amax Gold/Haile Mining, Anschutz Mining Corporation, Kemmerer Coal Company, Anaconda Copper Company, Southern Pacific Petroleum, Cambior Minerals, City of Brighton, Colorado Water Resources and Power Authority, University of Wisconsin, Dames and Moore, Advanced Sciences, Inc., and Earth Satellite Corporation.

While with the U.S. Geological Survey, Water Resources Division for six years, I was responsible for the design, management, and implementation of nine hydrogeological/geochemical studies. These studies covered the extent and magnitude of mining and mine drainage on the quality of Colorado streams; investigation of selenium and associated constituents at the margins of Rocky Flats Nuclear Facility; evaluation of existing and potential water quality problems from underground coal mines; evaluation of the hydrochemistry of thermal resources throughout Colorado; and investigation of the movement of chromium and other metals from tailings ponds into alluvium at Telluride, Colorado.

I have authored and co-authored over 38 technical papers on the environmental impacts of mining, mining regulation and the effects of mining activities on water quality. In particular, I have written reports on the geochemistry of selenium in groundwater, the effects of metal-mine drainage on water quality, arsenic at gold mining sites, and cyanide in mining-related waters. My Ph.D dissertation, published in 1974, dealt with hydrogeologic and geochemical issues at a mining district in Colorado. Several other technical papers have dealt with environmental hydrochemistry issues.

I have given technical presentations or been co-author on presentations given at: the Geological Society of America's Annual Meeting; the Meeting on Exploitation of Gold Deposits in Thrace, Greece; the Central Asian Ecology-99 Conference in Kyrgyzstan; the Third International Conference on Tailings & Mine Waste (co-author); the American Institute of Hydrology Meeting on Water Resources at Risk; the International Symposium on Acid Mine Water in Pyritic Environments (co-author); the Society of Mining Engineers Meeting (co-author); the International Symposium on Water-Rock Interaction in Czechoslovakia; and the American Water Resources Association's Meeting on Water Resources Problems Related to Mining.

I have participated in projects involving the use of cyanide in the mining industry for more than 30 years. Many of my publications have dealt with cyanide as it is used by the mining industry, including:

Moran, Robert E., 1998, Cyanide UncertaintiesCObservations on the Chemistry, Toxicity, and Analysis of Cyanide in Mining-Related Waters: Mineral Policy Center Issue Paper No.1, Wash., D.C.

Moran, Robert E., 2000, Cyanide in Mining: Some Observations on the Chemistry, Toxicity and Analysis of Mining-Related Waters: in Proc. Central Asia Ecology '99, Lake Issyk Kul, Kyrgyzstan, June,1999.

Moran, R.E., 2000, Cianuro: Algunos Conceptos Basicos: Informativo Mensual; Sociedad Nacional de Mineria, Petroleo y Energia, Vol. 9, no. 10, pg. 58-59.

Moran, R.E., 2001, More Cyanide Uncertainties: Lessons from the Baia Mare, Romania, Spill---Water Quality and Politics. Mineral Policy Center Issue Paper No. 3, Wash. D.C.

Moran, Robert E., 2002, De-coding Cyanide. A Submission to the European Union and the United Nations Environment Programme: Sponsored by Hellenic Mining Watch, Ecotopia, CEE Bankwatch, FOE Europe, FOE Hungary, FOE Czech Republic, Food First Information and Action Network, Minewatch UK, and Mineral Policy Center.

A true and correct copy of my resume is attached.

Red Dog Mine

I have examined the NPDES permit for Teck Cominco's Red Dog mine and the NPDES permit for the Red Dog port site. I have also examined the Discharge Monitoring Reports (DMRs) for the mine and port sites from 1998 to 2007, and laboratory reports for cyanide, TDS and WET from 1999-2007. I have also reviewed many of the letters from Teck Cominco to EPA admitting exceedances of Teck Cominco's NPDES permits. In the course of my Red Dog-related activities I have reviewed Teck Cominco's Opposition to Plaintiff's Motion for Partial for Summary Judgment ("Opposition") and the accompanying Affidavits / Declarations prepared by Mark Thompson (TDS, Cyanide, Plaintiffs' Miscellaneous Monitoring and Reporting Claims, WET Claims), James Kulas, Kevin Brix, and Edward Koon. As discussed below, I have also reviewed letters from James Kulas to Enoch Adams, Jr. discussing the reagents used at the mine. In addition, I have reviewed the documents listed in the references section of this report.

I toured the Red Dog mine facilities in 1996 while employed by Woodward Clyde Consultants.

The Teck Cominco Opposition repeatedly presents misleading statements regarding the chemical nature of the waste waters and the significance of total dissolved solids (TDS). At most regulated metal mine sites, relatively little regulatory attention is placed on the TDS content of the treated effluents. The major focus is normally on the chemical constituents in the waste waters that are potentially toxic to aquatic life, humans, etc.

At metal mine sites where no previous mining has occurred, the baseline (pre-mining) water quality depends on the extent to which the mineralized rocks have been exposed to weathering by water, air, wind, etc. In many cases, the ore body is buried at significant depths below the land surface so that the local rivers and ground waters often show little or no pre-mining evidence of elevated concentrations of chemical constituents.

At Red Dog, the mineralized rocks had been exposed by natural erosion within the Red Dog Creek drainage prior to initiation of mining activities. The erosion coupled with the natural formation of acid waters dissolved many of the chemical constituents in the local rocks, releasing them into the surrounding ground and surface waters. Hence, some sections of these drainages (and ground waters) had elevated baseline concentrations of numerous metals and some non-metals even prior to the commencement of any mineral exploration activities. These conclusions are well documented in the Environmental Baseline Studies conducted by Dames and Moore, in association with several other consulting firms (dated January 1983).

Despite the pre-existing natural contamination, it is totally disingenuous to imply that the subsequent mining and mineral processing activities have had no negative impacts on water quality. While relatively small volumes of mineralized rock had previously been exposed, once mining commenced the routine mining-related activities (road construction, exploration, drilling, blasting, open pit excavation, hauling of ore and waste rock, waste rock and ore stockpiling, etc.) all tremendously increased the volumes of mineralized rock that were exposed to the weathering elements (wind, water, bacteria, etc.). Now, the absolute quantities or volumes of chemical constituents released from the rock into the environment have significantly increased.

In addition, in order to separate and extract the desired metals from the ore, massive quantities of chemical reagents are added to the ore at the processing plant. A large percentage of these added chemicals is present in the processed waste, the tailings, either in their original forms or as other potentially-toxic decomposition products.

Thus, the Red Dog mine processing facilities receive geochemically-complex mixtures of rock and water: low pH, metals/metalloids containing elevated concentrations of many potentially toxic constituents such as: aluminum, antimony, arsenic, barium, cadmium, copper, chromium, cobalt, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc, together with elevated concentrations of the major metals (calcium, magnesium, sodium and potassium), nonmetals (sulfate, nitrate, ammonia, boron, phosphorus, fluoride, chloride), and natural radioactive constituents (uranium, thorium, potassium-40, gross alpha and beta, in general).

In addition, the processing facilities add chemical reagents such as the following: methyl isobutyl carbinol, potassium ethyl xanthate, sodium ethyl ether, potassium amyl xanthate, sodium isobutyl xanthate, sodium metabisulfite, zinc sulfate, copper sulfate, sodium cyanide, sodium sulfide, lime, sodium hydroxide, organic antiscalents and flocculents (correspondence: James Kulas, Teck Cominco to Enoch Adams, Jr., Oct. 11 and 13, 2002). Tons per year of most of these reagents are used in processing at Red Dog. For example, about 155 tons per year of sodium cyanide is used, which generates numerous cyanide and cyanide-related breakdown compounds (metal-cyanide complexes, cyanate, thiocyanate) as wastes. In addition, the mine utilizes significant quantities of

explosives [i.e. ANFO, ammonium nitrate-fuel oil, dynamite, etc.; for example, an average of 1,506,499 lbs of ANFO per day (Kulas letter to E. Adams, Oct.11, 2002)] and fuels (diesel, gasoline, kerosene), oils and lubricants, the residues of which are routed into the mine wastes and then to the treatment plant.

This chemically diverse "soup" of natural and industrial chemicals is far too toxic to be released directly into the environment, thus it is sent to the treatment plant for processing. However, the Opposition makes no mention of and cites no data for most of these chemical constituents in the monitoring of the treatment plant effluents.

The collective mass of all the dissolved chemical components in this chemically-complex "soup" can be determined in a laboratory. This sum is commonly referred to as total dissolved solids (TDS).

Total Dissolved Solids

Total Dissolved Solids (TDS) is a general measure of the chemical components dissolved in a water sample. There are several methods by which TDS can be determined, but most simply, they involve: 1) analytically determining a "complete" suite of the major and minor chemical constituents in the water and mathematically summing the results, or 2) evaporating the water sample to dryness and weighing the residue. Regardless of which method is employed, the laboratory reports the TDS concentration in milligrams per liter (mg / L). This reported TDS concentration, by itself, tells the observer nothing about the *detailed* chemical composition or toxicity of the water sampled.

In order to gain a detailed understanding of the chemical components actually present in a water sample--and indirectly represented by the TDS concentration—the sample must be analyzed for the detailed major and minor chemical components such as the reagents and rock constituents listed above, as a minimum.

Mining waste waters are often either highly acidic or highly alkaline (low or high pH), conditions which greatly increase the concentrations of dissolved and mobile chemical constituents. Many of these chemical constituents may be toxic to aquatic organisms and other life. Such is the situation at the Red Dog Mine. Most of the mine area water samples are acidic prior to treatment and are rendered highly alkaline during treatment. The rock constituents then become important components in the mine wastes and in the determination of TDS.

At the Red Dog Mine, or any similar metal mine, any measurement of TDS in an effluent sample would routinely be the sum of numerous major chemical constituents (i.e. calcium, magnesium, sulfate, bicarbonate, etc.), plus forms of numerous metals and metal-like elements such as arsenic, antimony, mercury, etc., together with forms of cyanide such as thiocyanate, cyanate, and various metal-cyanide complexes. It is totally misleading to refer to such wastes simply as TDS, or as a simple "calcium sulfate based TDS" as Teck Cominco has in filings with this Court.

As such, it is obvious that simply because water samples comply with NPDES or other

regulatory limits for total dissolved solids (TDS) content does not mean the TDS found in the water is benign or non-toxic.

Teck Cominco, the State of Alaska, and the US EPA have allowed TDS to become the main regulatory focus because this allows much simpler compliance monitoring for Teck Cominco and it also allows Teck Cominco to more simply control and adjust the volumes of treated effluent that can legally be discharged into Red Dog Creek. It does not, however, adequately reflect the actual toxicity of the effluents being discharged.

The original Outfall 001 discharge standard for TDS (196 mg/L) included in the 1998 NPDES permit was determined by the State of Alaska after reviewing the available baseline TDS data and adjusting it upward one-third. As such, it is clear that current end-of-pipe effluents that contain between 3000 and 3900 mg/L TDS represent a significant increase in the TDS concentration and load above baseline conditions. Such conditions seem to warrant conservative approaches on the part of the regulatory agencies. None of the biologic studies conducted by Teck Cominco or the State of Alaska have attempted to evaluate long-term impacts. As such, it seems only reasonable to conclude that the regulatory authorities have chosen not to employ conservative regulatory measures.

Teck Cominco has stopped reporting TDS at the discharge pipe (Outfall 001) every day, and now conducts conductivity measurements downstream with TDS measurements at the end of the pipe reported only once a week. Conductivity measurements taken downstream at Station 151 and Station 10 are directly correlatable with the TDS measurements at the pipe. Thus, TDS measurements at Outfall 001 that violate the permit can readily be correlated to conductivity measurements downstream, and vice versa. One can therefore reasonably estimate with confidence the TDS concentrations at Outfall 001 based on the conductivity measurements at Station 151 and Station 10. Based on the calculated TDS concentrations at Station 151 found in Teck Cominco's June 2004 DMR, it is apparent that the TDS concentrations of the discharge at Outfall 001 on June 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, and 15, 2004 were above 196 mg/L. According to the June 2004 DMR, the mine did not discharge on June 11 or 12, 2004.

In addition, based on the dates of Arctic Grayling spawning reported in the DMRs for 2005, 2006 and 2007, the TDS was above 170 mg/L (the monthly average permit limitation), on average, during spawning season in May 2005 (based on data from May 24, 25, 26, 27, 28, 29, 30, 31), June 2005 (based on data from June 1, 2, 3, 4, 5, 6), May 2006 (based on data from May 30, 31), June 2006 (based on data from June 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15), May 2007 (based on data from May 26, 27, 28, 29, 30 and 31) and June 2007 (based on data from June 1 and 2).

Red Dog TDS data are determined in the various commercial laboratories many days after the water samples were collected at the mine. Similar chemically-complex waters from mine sites all over the world are known to significantly change composition during the interval between sample collection and analysis. As a result, many of the dissolved constituents form solid particles and settle to the bottom of the bottle prior to the lab determination of TDS. Thus, it is unavoidable that the TDS concentrations routinely reported by Teck Cominco in the DMRs are lower than the actual

TDS concentrations in the treatment plant effluent (Outfall 001) that is discharged into Red Dog Creek.

Total Dissolved Solids Violations

I have reviewed the DMR and the lab results for TDS for June 1999, July 1999, August 1999, September 1999, and October 1999; May 2000, June 2000, July 2000, August 2000, September 2000, and October 2000; May 2001, June 2001, July 2001, August 2001, September 2001, and October 2001; May 2002, June 2002, July 2002, August 2002, September 2002, and October 2002; May 2003, June 2003, July 2003, and August 2003; May 2004, June 2004, July 2004, August 2004, and September 2004; May 2005, June 2005, July 2005, August 2005, September 2005 and October 2005; May 2006, June 2006, July 2006, August 2006, September 2006, and October 2006; May 2007, June 2007. The monthly average TDS results reported in those DMRs for each month are shown in the table below, in mg/L. I have calculated the annual average by averaging each monthly result.

Monthly Average TDS Concentrations, Outfall 001, 1999-2007 (in mg/L)

	1999	2000	2001	2002	2003	2004	2005	2006	2007
May	2713	3363	n.a.	1710	3580	2747	2997	3433	2770
June	3138	2647.5	3210	2995	3145	3410	3920	3538	3950
July	3210	n.a.	3290	3348	3473	3840	4039	3713	4070
August	3213	3132	2692	3463	3670	3836	4024	3660	--
September	3302	3063	3317	3442.5	n.a.	3770	3897	3943	--
October	3560	3200	3365	3340	n.a.	n.a.	4042	4110	--
Annual Average	3189	3081	3175	3050	3467	3521	3820	3732	3596

I have reviewed the DMR and the lab results for TDS for July 2005. The results are shown in the table below.

	mg/L
July 4, 2005	4090
July 10, 2005	3870
July 19, 2005	4020
July 26, 2005	4174

Monthly Average	4039

I have reviewed the DMR and the lab results for TDS for August 2005. The results are shown in the table below.

	mg/L
August 2, 2005	4122
August 9, 2005	3966
August 15, 2005	3958
August 21, 2005	3996
August 30, 2005	4076
Monthly Average	4024

I have reviewed the DMR and the lab results for TDS for September 2005. The results are shown in the table below.

	mg/L
September 5, 2005	3826
September 12, 2005	3864
September 19, 2005	3934
September 26, 2005	3964
Monthly Average	3897

I have reviewed the DMR and the lab results for TDS for October 2005. The October 3, 2005 TDS result was 4042 mg/L, which is both the daily maximum and the monthly average.

I have reviewed the DMR and the lab results for TDS for May 2006. The results are shown in the table below.

	mg/L
May 11, 2006	4116
May 15, 2006	4154
May 22, 2006	3134

May 29, 2006	2330
Monthly Average	3433

I have reviewed the DMR and the lab results for TDS for June 2006. The tests are summarized in the table below.

	mg/L
June 5, 2006	3580
June 12, 2006	3340
June 19, 2006	3480
June 26, 2006	3750
Monthly Average	3538

I have reviewed the DMR and the lab results for TDS for September 2006. The tests are summarized in the table below.

	mg/L
September 5, 2006	4050
September 10, 2006	3960
September 18, 2006	3880
September 24, 2006	3880
Monthly Average	3943

I have reviewed the DMR and the lab results for TDS for October 2006. The one TDS value reported, for October 1, 2006, is 4110 mg/L, which is both the daily maximum and the monthly average for October.

I have reviewed the DMR and the lab results for TDS for May 2007.

	mg/L
May 26, 2007	2800
May 28, 2007	2740
Monthly Average	2770

I have reviewed the DMR and the lab results for TDS for June 2007. The tests are summarized in the table below.

	mg/L
June 4, 2007	3610
June 10, 2007	4030
June 17, 2007	4000
June 25, 2007	4170
Monthly Average	3950

I expect that given the results from previous years, Teck Cominco will violate its TDS daily maximum permit limit of 3900 mg/L in July, August, September and October 2007, although I have not yet been provided with those DMRs.

Cyanide

Cyanide is a well-known poison, extremely toxic to humans and most forms of aquatic and terrestrial life. In addition, cyanide used at mining sites readily reacts to form other cyanide-related compounds which, while generally less toxic than cyanide itself, are nevertheless toxic to aquatic organisms. It is reasonable for the public to be concerned about the presence of cyanide in the water they drink. There are even more significant reasons for citizens to be concerned about the presence of cyanide and cyanide-related compounds in rivers from which they catch and consume fish. These concerns are reasonable even where measured cyanide concentrations (WAD or Total) are as low as a few tens of micrograms per liter.

The standard cyanide analytical techniques (free, WAD and Total) fail to detect many of the potentially toxic cyanide-related compounds that are often present in mining effluents. These compounds often include cyanate, thiocyanate and several metal-cyanide complexes. While it may be correct that the presence of these compounds makes accurate and precise analyses more difficult, the more relevant point is that these compounds can be toxic to aquatic organisms at very low concentrations. In addition, truly long-term studies on the toxicity of these compounds to aquatic life and humans are largely lacking.

All routinely-used analytical methods for the determination of cyanide in water and sediments have shortcomings, and present inherent problems with respect to providing accurate and reproducible (precise) data. Regulators, scientists and industry have been well aware of most of these difficulties for decades. Nevertheless, the discharge permit for site 001 was written requiring that the presence of cyanide be monitored using the Total Cyanide analytical method, and stipulated that the daily maximum and monthly average limits for total cyanide were 9µg/L (micrograms per liter) and 4µg/L, respectively.

Commercial laboratories are capable of quantifying cyanide samples near or below the daily maximum 9 ug/L and monthly average 4 ug/L limits. Teck Cominco's reports of cyanide levels that exceed daily maximum and monthly average limits of 9 ug/L and 4 ug/L respectively are reflective of actual violations of Teck Cominco's permit levels.

At Red Dog and other similar mineral processing sites, it is appropriate to monitor for Total Cyanide because it indirectly indicates the presence of several forms of toxic cyanide-related compounds which are not detected by WAD cyanide determinations, such as several of the metal-cyanide complexes. This is especially important for the common iron-cyanide complexes, which release toxic free cyanide when exposed to various intensities of artificial light and sunlight. Iron-cyanides are one of the main components in forest fire retardant compounds, which have been shown to be extremely toxic to fish. Recently, the EPA confirmed that iron-cyanide compounds are legally considered as cyanides. See Federal Register, pages 57690-57691 (October 6, 2003). Although EPA considers iron-cyanide complexes or compounds to be cyanide, they are not detected by WAD CN determinations.

Even where both Total and WAD Cyanide determinations are made, numerous forms of potentially toxic cyanide-related compounds are not detected, such as: thiocyanates, cyanates, selected metal-cyanide complexes (i.e. most cobalt and platinum cyanides), and most organic-cyanide compounds. It is disingenuous for Teck Cominco to claim that thiocyanate acts as an interference for the Total Cyanide method, but fail to mention that thiocyanate itself is also toxic to aquatic organisms — and is not detected in either the WAD or Total CN analyses.

Teck Cominco's repeated failure to meet the cyanide permit limitations lead me to be of the opinion that there is a reasonable likelihood that Teck Cominco will violate its cyanide permit limitations again in the future, if it has not done so already.

The Opposition presents partial and misleading explanations concerning the definition of the term "cyanide" and the related analytical techniques. Firstly, it is correct, as is stated on page 41 of the Opposition, that the term "cyanide" refers to a molecule containing one atom of carbon and one atom of nitrogen connected by a triple bond. However, what the Opposition fails to state is that there are numerous compounds that fit this definition, these compounds can be toxic to aquatic life, and they are not detected by the routinely used analytical techniques. For example, compounds such as thiocyanates, cyanates, cyanogen chloride, most cyanogens, various organic cyanide compounds, and several metal-cyanide complexes. Most of these compounds are less toxic to aquatic organisms than free cyanide, but they are nevertheless toxic. And, in the presence of sunlight, many of these compounds can release free cyanide. Most of these compounds have been reported in the wastes at metal mining sites, as can be verified by reviewing the findings in many of the references cited in paragraph 11.

The Oppositon has attempted to disregard the importance of these potentially-toxic, cyanide related compounds. In fact, largely through the Expert Report and deposition of Mr. Botz, they have presented the picture that the thiocyanates are merely compounds that create analytical interference. Yes, the thiocyantes may increase the variability in analytical results for cyanide, regardless of the test being performed. However, what is not mentioned is that the thiocyanates are also often present

in mine wastes---both solid and liquid wastes---and can be toxic to aquatic organisms. No data are presented by the Opposition for the presence or concentrations of thiocyanates, cyanates, or metal-cyanide complexes, or additional cyanide related compounds mentioned above, in the routine monitoring data. It seems quite likely that some of the unexplained WET test toxicity discussed by Mr. Brix in his declaration and deposition may be the result of some of these cyanide related compounds, which are not determined as part of Teck Cominco's monitoring.

In a similar vein, the Opposition attempts to totally discredit the Total Cyanide analytical method on the basis that the method has some degree of reporting variability when used to determine Total Cyanide in complex mining wastes. All analytical techniques are subject to variability---both sampling and analytical variability; the Opposition disingenuously fails to discuss the reporting variability for the WAD method. It also fails to mention that one important use for the Total Cyanide method is to detect the presence of cyanide-related compounds that are not detected by the WAD method.

This mine has been operated since 1989 and yet Teck Cominco has failed to publicly present detailed data from an adequate number of "blind" replicates (numerous identical samples; preferably at least 5 or 6, which have had different label designations affixed to the bottles so that the analysts would not be able to compare and duplicate the results) of water samples for both WAD and Total Cyanide analyses, conducted at one reliable laboratory. Such a program of quality assurance / quality (QA / QC) control is routinely conducted at most industrial and mining sites and research laboratories to allow the calculation of statistically-reliable estimates of reporting precision. Instead, Teck Cominco has reported analytical results from "split" samples (one of two identical samples, identically labeled, presumably), sent to two different labs. In at least one case, the Opposition discusses sending "split" samples, one sample each sent to three different laboratories. Such an approach does not allow one to statistically determine the method precision, and normally generates different results from each lab. Such an approach is guaranteed to generate uncertainty and confusion.

Most importantly, this approach has allowed Teck Cominco to simply choose among the determinations from the various labs, selecting those that seem most favorable for reporting on the official Discharge Monitoring Report forms. This is a totally unacceptable approach, and should not have been accepted by the regulatory officials of either the State of Alaska or the US EPA.

It appears that Teck Cominco has also failed to perform the same type of statistically-based quality assurance / quality control (QA/QC) blind replicate approach for the other monitored chemical constituents (such as lead, zinc, cadmium, selenium, total dissolved solids, etc.), in addition to WAD and Total Cyanide. Thus, how can the public determine the reliable reporting precision for these analyses? Baseline data have been collected at the Red Dog site since at least the early 1980s; an NPDES permit has been in effect since 1985, and the mine has been operational since 1989. Clearly these critical sampling / analytical reporting issues should have been evaluated many years ago---so that the public could have some confidence in the quantitative concentrations being reported. Under a system of self-monitoring, implementation of such a QA/QC program is the responsibility of the operating company.

The data reporting inadequacies cited above indicate that the various State and Federal regulatory agencies have chosen to "look the other way" when overseeing discharges from the Red Dog Mine site.

Total Cyanide Violations

For each month below, I include a table based on the total cyanide results from the lab reports and DMRs, which includes the results for each total cyanide test. Cyanide is sometimes abbreviated "CN." Here I present the concentrations in parts per billion ("ppb") which is the same as micrograms per liter (ug/L). The "Monthly Average" is my calculation based on averaging, by lab, the lowest value for each discrete date reported in the DMR's narrative portion and the lab reports, because the narrative portion of the DMR does not include this information. The "Monthly Average Reported in DMR" is the average reported in the DMR tables for that month; the column it is reported under is the lab Teck Cominco reported it was using for the monthly average value used in the table. If the lab reports differ from the results reported in the DMR, I note that.

The labs used by Teck Cominco to get test results for inclusion in its DMRs include ACZ Laboratories, Inc. ("ACZ"), Columbia Analytical Services, Inc. ("CAS"), CT&E Environmental Services, Inc. ("CT&E"), North Creek Analytical, Inc. ("NCA"), and Test America.

I have reviewed the DMRs for total cyanide for May 1999, June 1999, July 1999, August 1999, September 1999, May 2000, June 2000, July 2000, September 2000, October 2000, June 2001, July 2001, August 2001, September 2001, May 2002 and June 2002. The monthly average results from the DMRs are summarized in the following table. The monthly averages reported by Teck Cominco in each of these months violate Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb (and in May 2000 and June 2000 violate Teck Cominco's asserted permit limitation of 9 ppb).

MONTHLY AVERAGE TOTAL CYANIDE VALUES REPORTED IN DMRS	**1999-2002**
Month	Monthly Average Reported in DMR
May 1999	8.3 ppb
June 1999	7 ppb
July 1999	4.75 ppb
August 1999	7 ppb

September 1999	4.8 ppb
May 2000	13 ppb
June 2000	12 ppb
July 2000	5.2 ppb
September 2000	6.0 ppb
October 2000	"<5" ppb
June 2001	9 ppb
July 2001	5.8 ppb
August 2001	8.8 ppb
September 2001	6.7 ppb
May 2002	6.0 ppb
June 2002	4.5 ppb

I have reviewed the DMR and the lab results for total cyanide for May 2000. The results for May 25, 27 and 29 are summarized in the following table. All of the values for both labs violate the daily maximum in Condition I(A)(1) of 9 ppb; the DMR reports the maximum at 16 ppb.

MAY 2000 CN results	CAS	CT&E
May 25, 2000	16 ppb	41 ppb
May 27, 2000		24 ppb
May 29, 2000	16 ppb	29 ppb

I have reviewed the DMR and the lab results for total cyanide for June 2000. The results for June 10, 13 and 24 are summarized in the following table. The monthly maximum reported in the DMR, 19 ppb, violates the daily maximum in Condition I(A)(1) of 9 ppb.

JUNE 2000 CN results	CAS	CT&E
June 10, 2000	8 ppb	12 ppb
June 13, 2000	13 ppb	10 ppb
June 24, 2000		19 ppb

I have reviewed the DMR and the lab results for total cyanide for June 2001. The results are summarized in the following table. The daily results for CAS on June 12, and CT&E on June 14 and June 18, violate the daily maximum permit limitation in Condition I(A)(1) of 9 ppb. The monthly average reported in the DMR violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

JUNE 2001 CN results	CT&E	CAS
June 9, 2001		5 ppb
June 12, 2001		10 ppb
June 14, 2001	10 ppb	
June 18, 2001	12 ppb	5 ppb
June 27, 2001		5 ppb

I have reviewed the DMR and the lab results for total cyanide for July 2001. The results are summarized in the following table. The daily results for July 22 and July 30 violate Teck Cominco's daily maximum permit limitation in Condition I(A)(1) of 9 ppb. The monthly average reported in the DMR violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

JULY 2001 CN results	CT&E
July 17, 2001	9 ppb
July 22, 2001	10 ppb
July 30, 2001	10 ppb
Monthly Average Reported in DMR	5.8

I have reviewed the DMR and the lab results for total cyanide for August 2001. The results are summarized in the following table. Every single result from CT&E and the August 12 result from CAS violate Teck Cominco's daily maximum permit limitation in Condition I(A)(1) of 9 ppb. The monthly average reported in the DMR violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb, as do the averages of either lab's results.

AUGUST 2001 CN results	CAS	CT&E
August 2, 2001	6 ppb	
August 7, 2001	5 ppb	

August 12, 2001	10 ppb	17 ppb
August 13, 2001		13 ppb
August 16, 2001		13 ppb
August 20, 2001	5 ppb	21 ppb
August 26, 2001		20 ppb
Monthly Average Reported in DMR (results from both labs used per DMR)	8.8 ppb	

I have reviewed the DMR and the lab results for total cyanide for September 2001. The results are summarized in the following table. The September 1 CT&E result violates Teck Cominco's daily maximum permit limitation in Condition I(A)(1) of 9 ppb. The monthly average reported in the DMR violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

SEPTEMBER 2001 CN results	CAS	CT&E
September 1, 2001	3 ppb	11 ppb
September 6, 2001	5 ppb	
September 20, 2001	7 ppb	
September 24, 2001	7 ppb	
Monthly Average Reported in DMR (lab not specified)	6.7 ppb	

I have reviewed the DMR and the lab results for total cyanide for May 2002. The reported monthly average of 6 ppb violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

I have reviewed the DMR and the lab results for total cyanide for June 2002. The results are summarized in the following table. The June 10 result violates Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. The monthly average reported in the DMR violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

JUNE 2002 CN results	CAS
June 10, 2002	18 ppb
Monthly Average Reported in DMR	4.5 ppb

I have reviewed the DMR and the lab results for total cyanide for September 2002. The results are summarized in the following table. For those samples analyzed at the CAS lab, five of the ten samples tested over the cyanide daily permit limit of 9 ppb, with test results of 25, 10, 27, 10 and 37 ppb; the average of the 10 tests was 12 ppb. For those analyzed by the CT&E lab, nine of the ten tests were over the cyanide daily permit limit, with results of 28, 16, 23, 17, 24, 31, 22, 27 and 30 ppb, and an average of 22 ppb, more than twice the permit limit in Condition I(A)(1) of 9 ppb.

SEPTEMBER 2002 CN results	CAS	CT&E
September 24, 2002	7 ppb	
September 30, 2002 #1	25 ppb	28 ppb
#2	< 3 ppb	16 ppb
#3	< 3 ppb	23 ppb
#4	10 ppb	17 ppb
#5	3 ppb	24 ppb
#6	4 ppb	31 ppb
#7	4 ppb	< 5 ppb
#8	27 ppb	22 ppb
#9	10 ppb	27 ppb
#10	37 ppb	30 ppb
Average of Split Samples Reported in DMR	12 ppb	22 ppb
Monthly Average Reported in DMR (no lab specified)	1.8 ppb	

I have reviewed the DMR and the lab results for total cyanide for June 2003. The results are summarized in the following table. Conservatively setting "<3" result (June 17) equal to zero, I calculate the the CAS monthly average to be 6.25 ppb. Two of the three June 17 results and both June 24 results from CAS lab violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. The CAS monthly average violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

JUNE 2003 CN results	CAS	NCA
June 3, 2003	8 ppb	1.52 ppb

June 10, 2003	7 ppb	2.6 ppb
June 17, 2003	10 ppb	2.75 ppb
	25 ppb	
	<3 ppb	
June 24, 2003	10 ppb	0.85 ppb
	13 ppb	
Monthly Average	6.25 ppb	1.93 ppb
Monthly Average Reported in DMR		2.0 ppb

I have reviewed the DMR and the lab results for total cyanide for July 2003. The results are summarized in the following table. Conservatively using the lowest result for July 15 and July 29, the CAS monthly average is 10.25. Both of the July 15 and July 29 results from CAS violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. The CAS monthly average violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

JULY 2003 CN results	CAS	NCA
July 1, 2003	8 ppb	<0 .6 ppb
July 8, 2003	3 ppb	<0.6 ppb
July 15, 2003	20 ppb	0.65 ppb
	22 ppb	
July 18, 2003		2.68 ppb
July 29, 2003	12 ppb	3.52 ppb
	10 ppb	
Monthly Average	10.25 ppb	1.71 ppb
Monthly Average Reported in DMR		1.4 ppb

I have reviewed the DMR and the lab results for total cyanide for August 2003. The results are summarized in the following table. The CAS monthly average violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

AUGUST 2003 CN results	CAS	NCA
August 12, 2003	7 ppb	< 0.6 ppb
Monthly Average	7 ppb	<0.6 ppb
Monthly Average Reported in DMR		.04 ppb

I have reviewed the DMR and the lab results for total cyanide for May 2005. The results are summarized in the following table. All three NCA results and the ACZ result on May 23, 2005 violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. Conservatively taking the lowest daily results for May 23, the NCA average is 7.47 ppb. Setting the non-detect values for May 14 and May 19 to zero, the ACZ average is 5.67 ppb. Both monthly averages violate Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb. Although Teck Cominco reports in the DMR using ACZ's results in the table, the table value for daily maximum reported by Teck Cominco is "<3" while the actual maximum value reported by ACZ for May 2005 is 17 ppb.

MAY 2005 CN results	ACZ	NCA
May 14, 2005	< 3 ppb (n.d.)	1.42 ppb
(2nd result not reported in DMR)	< 3 ppb (n.d.)	
May 19, 2005	< 3 ppb (n.d.)	3.38 ppb
May 23, 2005	17 ppb	18.5 ppb
(2nd result not reported in DMR)		20.8 ppb
(3rd result not reported in DMR)		17.6 ppb
(4th result not reported in DMR)		23.4 ppb
Monthly Average	5.67 ppb	7.47 ppb
Monthly Average Reported in DMR	<3	

I have reviewed the DMR and the lab results for total cyanide for August 2005. The results are summarized in the following table. Both of the daily results from NCA on August 9, 2005 violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. Conservatively taking the

lower of the two daily results for August 9, the NCA average is 5.68 ppb, which violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

AUGUST 2005 CN results	ACZ	NCA
August 2, 2005	<3 ppb	4.78 ppb
August 9, 2005	3 ppb	12.8 ppb
(2nd result not reported in DMR)		18.5 ppb
August 15, 2005	5 ppb	5.2 ppb
August 21, 2005	<3 ppb	3.18 ppb
August 30, 2005	<3 ppb	2.42 ppb
Monthly Average	1.6 ppb	5.68 ppb
Monthly Average Reported in DMR	<9	

I have reviewed the DMR and the lab results for total cyanide for September 2005. The results are summarized in the following table. All of the daily results from both labs on September 5, September 12, and September 19, 2005 violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. Conservatively taking the lower of the two daily results for each date, and using zero as the input for the non-detect on September 26, 2005, the NCA average is 16.53 ppb. Using the lower result on September 5, 2005, the ACZ average is 8.75 ppb. Both monthly averages violate Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb (and the NCA average violates the limitation of 9 ppb claimed by Teck Cominco). In the DMR table, Teck Cominco reported one exceedance for daily cyanide with a maximum value of 10 ppb.

SEPTEMBER 2005 CN results	ACZ	NCA
September 5, 2005	10	14.2
	22	25
September 12, 2005	10	22.4
	24.5	24.5
September 19, 2005	10	13.0
		13.1

September 26, 2005	5	<0.6 (n.d.)
Monthly Average	8.75 ppb	16.53 ppb
Monthly Average Reported in DMR	<9	

I have reviewed the DMR and the lab results for total cyanide for October 2005. The results are summarized in the following table. The NCA results of 10.8 ppb and 12.3 ppb violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. The NCA monthly average of 11.55 ppb and the ACZ monthly average of 9 ppb both violate Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb (and the NCA average violates the limitation of 9 ppb claimed by Teck Cominco). In the narrative portion of the DMR, Teck Cominco reveals that it is reporting the "ACZ sulfide fixed total cyanide result" in the tables; the sulfide field fixed result from ACZ for October 3, 2005 is 7 ppb, which violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

OCTOBER 2005 CN results	ACZ	NCA
October 3, 2005	9 ppb	10.8 ppb
		12.3 ppb
Monthly Average	9 ppb	11.55 ppb
Monthly Average Reported in DMR	<9	

I have reviewed the DMR and the lab results for total cyanide for May 2006. The results are summarized in the following table. The ACZ daily results of 10 ppb on May 11, 2006 and of 13 ppb on May 15, 2006 violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. The ACZ average of 10.25 violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb (and the limitation of 9 ppb claimed by Teck Cominco).

MAY 2006 CN results	ACZ	Test America
May 11, 2006	10 ppb	3.1 ppb
May 15, 2006	13 ppb	2.7 ppb
May 22, 2006	9 ppb	3.8 ppb
May 29, 2006	9 ppb	< 0.6 ppb (n.d.)
Monthly Average	10.25 ppb	2.4 ppb

Monthly Average Reported in DMR		<9

I have reviewed the DMR and the lab results for total cyanide for June 2006. The results are summarized in the following table. The ACZ daily result of 19 ppb on June 5, 2006 violates Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. Conservatively taking the lower of the two test values from ACZ for June 19, 2006, the monthly average of ACZ's results is 10.5 ppb. The Test America monthly average is 5.09 ppb. Both averages violate Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb (and the ACZ average violates the limitation of 9 ppb claimed by Teck Cominco).

JUNE 2006 CN results	ACZ	Test America
June 5, 2006	19 ppb	7
June 12, 2006	8 ppb	2.72 ppb
June 19, 2006	7 ppb	3.15
(2nd sample not reported in DMR)	8 ppb	
June 26, 2006	8 ppb	7.48
Monthly Average	10.5 ppb	5.09 ppb
Monthly Average Reported in DMR		<9

I have reviewed the DMR and the lab results for total cyanide for July 2006. The results are summarized in the following table. Taking the test values from ACZ reported in the DMR for July 4 and July 10, 2006, the monthly average of ACZ's results is 8.0 ppb (conservatively taking the lower of the two value for July 4 and July 10 yields an average of 7.75 ppb, which does not change the overall conclusion about compliance for July 2006). The monthly average of the Test America results is 4.125 ppb. Both averages violate Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

JULY 2006 CN results	ACZ	Test America
July 4, 2006	7 ppb	5.9 ppb
(2nd result not reported in DMR)	6 ppb	
July 10, 2006	8 ppb	3.18 ppb

(2nd result not reported in DMR)	9 ppb	
July 17, 2006	9 ppb	3.78 ppb
July 24, 2006	8 ppb	3.62 ppb
Monthly Average	8.0 ppb	4.12 ppb
Monthly Average Reported in DMR		<9

I have reviewed the DMR and the lab results for total cyanide for August 2006. The results are summarized in the following table. Using the test results reported in the DMR, the ACZ monthly average of 6.2 ppb violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb. (Using a value of zero for the non-detect on August 7, 2006, the monthly average of Test America's five tests is 2.72 ppb.)

AUGUST 2006 CN results	ACZ	Test America
August 1, 2006	6 ppb	3.81 ppb
August 7, 2006	5 ppb	<1.2 ppb (n.d.)
August 14, 2006	8 ppb	3.35 ppb
August 20, 2006	6 ppb	2.55 ppb
(2nd value not reported in DMR)	7 ppb	
August 27, 2006	6 ppb	3.9 ppb
Monthly Average	6.2 ppb	2.72 ppb
Monthly Average Reported in DMR		<9

I have reviewed the DMR and the lab results for total cyanide for September 2006. The results are summarized in the following table. Both labs monthly averages violate Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

SEPTEMBER 2006 CN results	ACZ	Test America
September 5, 2006	7 ppb	6.55 ppb

September 10, 2006	6 ppb	5.08 ppb
September 18, 2006	4 ppb	7.2 ppb
September 24, 2006	4 ppb	2.22 ppb
Monthly Average	5.25 ppb	5.26 ppb
Monthly Average Reported in DMR		<9

I have reviewed the DMR and the lab results for total cyanide for October 2006. The results are summarized in the following table. The Test America monthly average of 9 ppb violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb.

OCTOBER 2006 CN results	ACZ	Test America
October 1, 2006	< 5 ppb	9 ppb
Monthly Average	<5 ppb	9 ppb
Monthly Average Reported in DMR	<5.0 ppb	

I have reviewed the lab results for total cyanide for August 2007. The results are summarized in the following table. The monthly average of ACZ's tests was 6.25 ppb, which violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb. (Using zero as the value for the non-detect on August 6, Test America's tests averaged 3.285 ppb for the month.)

AUGUST 2007 CN results	ACZ	Test America
August 1, 2007		1.28 ppb
		< 0.9 ppb (n.d.)
August 6, 2007	7 ppb	2.98 ppb
	5 ppb	3.68
August 13, 2007	6 ppb	
August 20, 2007	7 ppb	4.65 ppb
		7.12 ppb
Monthly Average	6.25 ppb	3.285 ppb

I have reviewed the lab results for total cyanide for September 2007. The results are summarized in the following table. The results of 20.0 ppb and 37.1 ppb on September 10, 2007 violate Teck Cominco's permit limitation in Condition I(A)(1) of 9 ppb. The Test America monthly average of 10.31 ppb violates Teck Cominco's permit limitation in Condition I(A)(1) of 4 ppb (and violates the limitation of 9 ppb claimed by Teck Cominco).

SEPTEMBER 2007 CN results	Test America
September 10, 2007	20.0 ppb
	37.1 ppb
	2.45 ppb
September 16, 2007	2.42 ppb
	2.82 ppb
September 24, 2007	2.95 ppb
	4.45 ppb
Monthly Average	10.31 ppb

I understand from plaintiffs' counsel that the October 2007 reported monthly average and daily maximum result was 32 ppb, but Teck Cominco did not provide plaintiffs with the October 2007 DMR in time for me to review it before completing this expert report. This result is eight times the monthly average permit limit, and almost four time the daily maximum limit for total cyanide.

Whole Effluent Toxicity

The Red Dog mine uses massive quantities of numerous reagents in its processing of the mine ore. According to information sent by Teck Cominco to KRPC, these reagents include: 53 tonnes/year (tpy) Methyl Isobutyl Carbinol, 587 tpy Potassium Ethyl Xanthate, 891 tpy potassium amyl xanthate, 319 tpy sodium metabisulfite, 455 tpy zinc sulfate, 5375 tpy copper sulfate, 155 tpy sodium cyanide, 324 tpy sodium sulfide, 8818 tpy line, 41 tpy antiscalent, and 94 tpy flocculent. These figures are based on the letter from James Kulas, environmental manager at Red Dog, to Enoch Adams, Jr., Chair of KRPC, on October 13, 2002, which I have reviewed.

I have also reviewed the letter from James Kulas, environmental manager at Red Dog, to Enoch Adams, Jr., Chair of KRPC, on October 11, 2002 and its attachment.

Routine monitoring of Teck Cominco's effluent and the waters impacted by Teck Cominco's discharges do not directly survey for most of these reagents. Many of these reagents or their breakdown products would likely be in the total load discharged by Teck Cominco.

Because the 2002 water sampling near Kivalina was performed in December, when the Red Dog treatment plant was not discharging, these samples are not likely to be representative of the water quality in the Wulik River during months when mine discharge does occur.

The fact that water meets drinking water standards for certain parameters does not necessarily mean it is safe for human or animal consumption or is non-toxic to aquatic life. Mining effluents, even treated effluents that comply with all NPDES limits for specific chemicals, may still be toxic to aquatic organisms. This conclusion has often been verified by various forms of toxicity testing in both the United States and Canada. While the exact explanation is usually unclear, it is likely that the effluents contain concentrations of some chemical constituents not included in the list of monitored constituents. WET tests provide the best synoptic means of evaluating the overall toxicity of such chemically-complex effluents.

The fact that water samples comply with NPDES or other regulatory limits for total dissolved solids (TDS) content does not mean the TDS found in the water is benign or non-toxic.

The mine is required by its NPDES permit to perform whole effluent toxicity tests, also known as WET tests. Under the permit, the WET tests involve the use of a species of water flea, *Ceriodaphnia dubia*, and a small fish, *Pimephales promelas*. These WET tests are used precisely because of the complexities mentioned above. That is, these organisms are exposed to various concentrations of the effluent to determine the degree to which it may be toxic. WET tests often indicate potential toxicity even though the concentrations of all chemical constituents determined in the water sample are in compliance with the NPDES limits.

The repeated failure of the mine's WET tests (Teck Cominco has reported violations to EPA of its WET permit limits in September 1998, May 1999, July 1999, August 2000, August 2001, and September 2002) indicates that the effluent is, indeed, toxic to some forms of aquatic life in the receiving water. The WET permit levels are also high enough that the water may often be toxic to aquatic organisms even when it complies with the permit limits.

The repeated failures of the WET test at the mine make Kivalina residents' concerns about the impact of the mine's effluent on fish and other water-borne life reasonable.

TDS, cyanide, cadmium and other chemical constituents discharged by Teck Cominco into the Middle Fork Red Dog Creek will flow downstream with the regular stream flow, entering the Main Stem Red Dog Creek, the Ikalukrok Creek, and the Wulik River, in turn. Once in the Wulik they will flow downstream to the mouth of the Wulik with the regular flow of the river. If Kivalina residents take drinking water from the Wulik River, some contaminants discharged by the mine are likely to be in that water. It is reasonable for the residents to fear the presence of these contaminants in their drinking water.

<u>Other Observations</u>

Numerous mines are operated worldwide within the arctic, and most of them collect specific conductance (S.C.) measurements of water samples using some form of automated equipment. All

experience some degree of equipment failures and data transmission problems due to human error and the harsh arctic weather. Nevertheless, most of these sites are capable of using the S.C. measurements to make estimates of TDS, based on the relationships of historical S.C., temperature and lab-determined TDS data.

The Red Dog site has water quality data from the early 1980s, much of which includes S.C. and lab-determined TDS, thus an historic relationship was obviously available when the mine permit was written. Partly on the basis of the historic data, from 1998 until June 15, 2004 the permit includes a daily maximum TDS limitation of 196 mg/L, which was then raised to 3900 mg/L. The permits allowed TDS concentrations to be calculated using site historical S.C. data. However, the mine treatment plant effluent (site 001) frequently violated this TDS permit limit. Teck Cominco states that these exceedances were not truly permit violations because its staff had been using incorrect conversion factors for calculating TDS, which were revised on the basis of data from 1999 and 2000. However, Teck Cominco has had relevant historical water quality data from the early 1980s through the 1990s that should have allowed determination of an appropriate conversion factor to calculate TDS. Only after a lawsuit was filed documenting numerous TDS permit violations did Teck Cominco then seek to revise the conversion factors. It is reasonable to conclude that the originally-reported TDS violations represent actual violations, despite being calculated using pre-1999-2000 conversion factors.

The treated effluent at site 001 and numerous other non-point sources around the mine add significant volumes of TDS and other chemical constituents in both dissolved and particulate forms into the Middle Fork Red Dog Creek. While much of the chemical load released into the drainage system is originally in dissolved form, it rapidly converts into particles which settle to the stream bottom. These particles are partly composed of metal compounds, and metal-cyanide compounds, many of which may be ingested by benthic organisms and fish, leading to toxic responses in the aquatic communities.

In my experience, having independent on-site oversight or inspections of mining facilities improves the incentives for those mining facilities to comply with their permit limitations. These independent observers must have formal training in environmental monitoring and data interpretation.

Any long-term solution to Teck Cominco's violations must take into account the actual toxicity of the effluent, and include more detailed laboratory analyses than are currently required by Teck Cominco's permits, including both organic and inorganic chemical constituents. These samples should be independently collected and analyzed, and should be taken at regular intervals during the operation of the mine and the port site.

If these independent analyses confirm degradation of the receiving waters, then additional water treatment facilities or technologies should be required at the port and the mine.

Loads

When considering the impacts of Red Dog discharges to the environment and their potential impacts on local and regional water quality and aquatic life, it is imperative that all sources of releases to the aquatic environment are evaluated. This would include releases of water quality constituents in dissolved, colloidal and suspended forms. Aquatic organisms are capable of ingesting chemical constituents both from the water column and the bottom sediments.

Because aquatic organisms are capable of ingesting chemical constituents in both dissolved and particulate forms, it is necessary to monitor and evaluate data on contaminant loads released into the environment, in addition to concentrations when evaluating potential changes in the water quality and toxicity of the Red Dog area drainages. Load is the mass of a chemical constituent, such as TDS, released from or mobile at that site. Loads are calculated by multiplying the chemical constituent concentration by the stream flow or discharge volume at that site. The Opposition fails to discuss or present any data on either detailed bottom sediment chemical composition or the loads of TDS and other individual chemical constituent loads discharged from Outfall 001.

Given all of the detailed discussion in the Opposition about the improved methods employed to estimate stream flow, it seems reasonable that they should also present detailed data (recent and historic) on contaminant loads present at 001 and other downstream sites.

Non-point Sources of Contaminants

The Red Dog tailings impoundment is largely unlined and comparable facilities all over the world normally release considerable contaminated seepage. As a minimum, one would expect that over all the years this mine has operated, that Teck Cominco would have conducted a simple seepage survey along Red Dog and Ikalukrok Creeks. Such surveys routinely involve making field measurements (along both banks of the rivers) of water temperature, pH, and conductivity---to target the locations of non-point sources of inflow to the drainages. The Opposition presents no data or discussion on the contaminant contributions such non-point seepage might be making to the local drainages.

In addition, given statements in the various reports by Teck Cominco's consultant Gene Andrews regarding the unexpected volumes of water encountered at Red Dog, it is also reasonable to assume that data on both point source and non-point source releases should be considered in evaluating the impacts of the Red Dog project on local water quality. Mr. Andrews has failed to address these issues.

Data Sources

All of the official monitoring data is provided by Teck Cominco and or their paid consultants. In most other arenas (such as pharmaceutical studies, or financial and accounting evaluations of corporations) such conditions have been found to be unacceptable and prone to presenting a biased picture. As a minimum, many of the data deficiencies noted above need to be evaluated via independent studies that are independently funded and directed.

For example, in the last paragraph of page 25, the Opposition reveals that TDS estimates are automatically overstated by 5 percent. From Teck Cominco's point of view there are logical reasons for doing so, but this is a marvelous example of how the public must totally rely on the company-generated data---in an arena where the company is being regulated. This is largely self-regulation.

Kevin Brix and WET testing

Kevin Brix has stated in both his declaration and deposition that roughly 50 percent of the toxicity noted in the various whole effluent toxicity (WET) tests results from the TDS components. Yet, he feels comfortable that the proposed increases in the allowable TDS concentrations in Red Dog effluents will not result in any significant impacts to the aquatic biota. Given the lack of long-term testing, and the evidence of negative impacts to arctic grayling in Brix's own studies, this conclusion seems premature at best. In addition, he has failed to evaluate the potential toxicity of most of the minor and trace constituents that are likely present in both the dissolved and particulate portions of the discharged effluent, and in the river sediments.

Teck Cominco has failed to collect monitoring data for numerous chemical constituents in both its effluent and ambient monitoring that are known to be toxic to aquatic life and human health if present in excessive concentrations in both sediments and water. These include, for example, antimony, arsenic, thallium, molybdenum, vanadium, gross alpha and beta radioactivity, uranium, nitrate, sulfate, chloride, numerous organic compounds, thiocyanate, cyanate, chloramines, numerous metal-cyanide complexes and others. It seems likely that the presence of many of these and other undetermined chemical constituents discharged into the Red Dog surface waters could be the cause for much of the unexplained toxicity mentioned in Mr. Brix's opinions.

On pages 65 and 66 of the Opposition, Mr. Brix is cited as support for the statements that the August 2004 WET Test results from Outfall 001 were obtained from "split" samples analyzed at three different laboratories: ENSR, CH2M Hill, and the University of Miami. The three WET test results were reported to be 9.28, 13.6, and 5.6 TUc, respectively. On the basis of these results Mr. Brix has stated that the results obtained at the U. of Miami support those from the ENSR lab, despite the significantly different results. This conclusion does not seem reasonable as it is unlikely that analyses of "split" samples at all three labs could have been completed within the required holding times for valid WET tests. In order to better evaluate the validity of these statements, one would need to know the exact date on which the sample was collected (and presumably split), and the dates on which all three of the WET determinations were begun and completed. None of these details are available to me at this time. It seems quite likely that the test performed by Mr. Brix at the U. of Miami was conducted at a later date than the original test. If so, the dissolved gas content of the water sample would likely have altered, thereby producing significant changes in the water chemistry and altering the measured toxicity. As such, it is reasonable to assume that the "split" WET analysis test performed by Kevin Brix at the University of Miami does not adequately represent the chemical conditions in the original sample collected from Outfall 001.

Redressability

Simply because no formal water quality standards have been exceeded does not mean that potentially toxic conditions do not exist. For example, Teck Cominco fails to monitor for numerous

chemical constituents that are frequently found in mining wastes, and which are not included in the requirements of the Red Dog NPDES permit. These include, for example: antimony, arsenic, thallium, molybdenum, vanadium, gross alpha and beta radioactivity, uranium, nitrate, sulfate, chloride, numerous organic compounds, thiocyanate, cyanate, chloramines, numerous metal-cyanide complexes and others. Nor are most of the chemicals used as reagents, listed above, tested for. If no analysis is performed for these constituents, it does not mean that they are not present in the mine discharges, the receiving streams, or in the ground waters.

In addition, metal mining sites routinely discharge chemical constituents that accumulate in the bottom sediments of the receiving rivers. These constituents may originally have been released as chemical compounds that were previously in dissolved form, but which converted to other solid compounds and settled to the river bottom (precipitated), after entering the receiving river. In the bottom sediments, these chemical constituents can accumulate, increase in concentration, and can be converted to other toxic compounds through the mediation of microorganisms. Benthic aquatic organisms routinely consume such solid particles, causing them to accumulate in their bodies. These organisms are then consumed by higher organisms, such as fish, birds, etc. Hence, the chemical constituents can be concentrated up the food chain, presenting hazards to the aquatic, terrestrial and human populations.

River or lake bottom sediments can accumulate all of the metals, non-metals, nutrients, cyanide compounds, non-volatile fractions of fuels and chemical reagents discussed above.

All of these processes can occur in the stream bottom sediments even though no regulated chemical constituents were reported at excessive concentrations in the water samples.

The Opposition and its supporting documents fail to discuss the detailed chemical composition of either the river bottom sediments or the aquatic biota in either the Red Dog project area or in the region of Kivalina.

Snowmelt Dilution

Contrary to the Opposition's claims on page 35, it is absolutely expectable to observe that the TDS concentrations at Station 1 (in Kivalina) are actually lower during months when the Red Dog Mine is discharging (routinely May to October) as compared to the months when there is no permitted discharge. During winter months at mine sites located at either high elevation or high latitude most of the available water is frozen as snow or ice. Thus, the snowmelt is not available to mix with the other sources of water. Hence, the winter constituent concentrations in such rivers routinely tend to be higher, and are routinely lower in the warmer months once snowmelt is available to promote dilution.

Reasonable Concern in Kivalina

Contrary to the assertions in the Opposition (at 98), it is quite reasonable for the citizens of Kivalina and neighboring areas to fear the potential impacts of cyanide and other chemical constituents in the local sections of the Wulik River. It must be remembered that the Red Dog Mine releases massive volumes of waste to Red Dog Creek; it is permitted to discharge up to 2,418,000,000 gallons per year, or an *average* of 16,200,000 gallons each day.

It is obvious from sediment studies at similar metal mine settings that wastes discharged by the mine release chemical constituents into the receiving streams and that many of these constituents form bottom sediments. Following every significant increase in river flow, such as during spring snowmelt, or following large rainfall events, these bottom sediments migrate downstream, often great distances.

Given that many of the potentially toxic compounds found in the Red Dog tailings together with the treatment plant chemical reagents are released as part of the treated effluent, they are liable to migrate downstream as either dissolved compounds or as particles. As discussed above, many of the potentially toxic constituents often found in mining wastes are not included in the routine monitoring at Red Dog. Such constituents include for example, antimony, arsenic, thallium, molybdenum, vanadium, gross alpha and beta radioactivity, uranium, nitrate, sulfate, chloride, numerous organic compounds, thiocyanates, cyanates, chloramines, numerous metal-cyanide complexes and others. In addition, Teck Cominco has not presented detailed data on the chemical contents of the river sediments downstream of Outfall 001.

Clearly it is reasonable for the citizens of Kivalina to be concerned about the possible presence of these constituents as they can be consumed by benthic (bottom-dwelling) aquatic organisms and then accumulated up the food chain as they are consumed by fish, birds, and humans.

I have read the deposition testimony of Mark Thompson of Teck Cominco in which he describes TDS discharged from the mine Outfall 001 ending up at the Village of Kivalina. I agree with Mr. Thompson's loading analysis, that if TDS is discharged at Outfall 001, some of it will end up in the Wulik River at Kivalina and in the Kivalina drinking water supply taken from that River.

Clearly, there would be almost no mine-related contribution to the TDS concentrations in Kivalina if Teck Cominco had abided by the 1998 NPDES permit limit of 196 mg/l of TDS. If Teck Cominco released 1/20th of the present TDS load, then only 1/20, of the TDS load could migrate downstream.

Testimony on the Gene Andrews Expert Report.

Mr. Andrews (Expert Report, 2004, Attachment 1, pg. 15-16) states that mine water treatment has converted the Red Dog waters from largely toxic to non-toxic and uses the Pre-and Post-Mining TDS compositions as evidence (Table 2, page, 15). Unfortunately, TDS in no way provides any specific chemical information. Also, Table 2 contains ranges of data only for: hardness, TDS, sulfate, cadmium, copper, lead, and zinc, and neglects to report the dozens of other constituents likely present.

However, the Red Dog mine processing facilities receive geochemically-complex mixtures of rock and water [low pH, metals/metalloids (elevated concentrations of many potentially toxic constituents such as: aluminum, antimony, arsenic, barium, cadmium, copper, chromium, cobalt, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc, together with elevated concentrations of the major metals: calcium, magnesium, sodium and potassium), and nonmetals [sulfate, nitrate, ammonia, boron, phosphorus, fluoride, chloride], and natural radioactive constituents (uranium, thorium, potassium-40, gross alpha and beta, in general).

Two recent papers document the presence of most of these constituents in the Red Dog rocks

(Slack et.al., 2004a and b). Other chemical constituents listed above, but not mentioned in the Slack papers are listed because they are almost always present in metal mine effluents.

In order to separate and extract the desired metals from the ore, the following chemical reagents are added: methyl isobutyl carbinol, potassium ethyl xanthate, sodium ethyl ether, potassium amyl xanthate, sodium isobutyl xanthate, sodium metabisulfite, zinc sulfate, copper sulfate, sodium cyanide, sodium sulfide, lime, sodium hydroxide, organic antiscalents and flocculents (correspondence: James Kulas, Teck Cominco to Enoch Adams, Jr., Oct. 11 and 13, 2002). Tons per year of most of these reagents are used in processing at Red Dog. For example, about 155 tons per year of sodium cyanide is used, which generates numerous cyanide and related breakdown compounds (metal-cyanide complexes, cyanate, thiocyanate) as wastes. In addition, the mine utilizes tremendous quantities of explosives [i.e. ANFO, ammonium nitrate-fuel oil, dynamite, etc.; for example, an average of 1,506,499 lbs of ANFO per day (Kulas letter to E. Adams, Oct.11, 2002)] and fuels (diesel, gasoline, kerosene), oils and lubricants, the residues of which are routed into the mine wastes and then to the treatment plant.

This chemically diverse "soup" of natural and industrial chemicals is far too toxic to be released directly into the environment, thus it is sent to the treatment plant. However, Andrews makes no mention of and cites no data for most of these chemical constituents in the monitoring of the treatment plant effluent samples and other samples.

Andrews, in his expert report, fails to present any ion balances, complete or incomplete, to demonstrate that the TDS data he uses are reasonable and reliable. Nevertheless, he alleges that, since mining and water treatment have commenced, that the discharge and TDS have become benign, or non-toxic to aquatic organisms. He fails to present data adequate to substantiate these statements.

Total Dissolved Solids (TDS) is a *general* measure of the chemical components dissolved in a water sample. There are several methods by which TDS can be determined, but most simply, they involve: 1) analytically determining a "complete" suite of the major and minor chemical constituents in the water and mathematically summing the results, or 2) evaporating the water sample to dryness and weighing the residue. *Regardless of which method is employed, the laboratory reports the TDS concentration in milligrams per liter (mg / L), and this result, by itself, tells the observer nothing about the specific chemical composition or toxicity of the water sampled.*

In order to gain a detailed understanding of the chemical components actually present in a water sample--and indirectly represented by the TDS concentration—the sample must be analyzed for a wide range of major and minor chemical components. The major ions should include, as a minimum, silica, calcium, magnesium, sodium, potassium, alkalinity, sulfate, chloride, and nitrate (Skougstad, et.al, 1979). However, when water samples are either acidic or highly alkaline, numerous minor constituents become dissolved at significant concentrations and become important components in the determination of TDS. Many of these normally minor chemical constituents may be toxic to aquatic organisms and other life. Such is the situation at the Red Dog Mine. Most of the water samples are acidic prior to treatment and are rendered highly alkaline during treatment.

According to data in Scannell (1996), treated effluents released to Red Dog Creek from NPDES site 001 during 1995 often had pH values as high as 10. Similar elevated pH levels, sometimes above 10,

are reported on the site 001 DMRs for 1999—2003 and into 2004. Clearly such effluents would be toxic to many aquatic organisms strictly on the basis of elevated pH. In addition, evidence from numerous other mine sites shows that such high pH treated effluents often contain elevated concentrations of many potentially toxic minor constituents, either in solution or as microparticles.

The opinions presented by Mr. Andrews in his Expert Report, Nov.15, 2004, concerning the feasibility of various water treatment options should be, of necessity, based on detailed, high quality data on flow and water quality. However, Mr. Andrews fails to present a **detailed** summary of the overall water quality data, both influent and effluent, on which he bases his opinions. In fact, in Attachment 1 of his Expert Report (Andrews, Aug. 1997), at the top of page 16, he states: "Though a complete data set is not available for each of the various sampling periods or sample points, several facts are illustrated in the table:" In fact, the table referred to by Mr. Andrews summarizes almost none of the available data and very little of the important data necessary to adequately evaluate the treatment options. As mine operations began in 1989, this lack of detailed data summary is an unreasonable excuse for the failure to perform a detailed analysis.

The geochemical data presented in Slack (2004 a, and b) indicate that the Red Dog rock contains significant concentrations of many potentially toxic metalloids, two of which are arsenic and antimony. Nevertheless, Andrews fails to present any water quality data in Table 2 of Attachment 1 to his Expert Report (Nov. 15, 2004) on the presence of either arsenic or antimony. Table 1 of the same report does show the treated *effluent* concentration for arsenic, but reports the concentration as < 2 mg/L. Such a detection limit is far too high to be useful or meaningful in terms of evaluating the potential toxicity to receiving waters. Because this table fails to report the *influent* arsenic concentration, it is also not useful for evaluating the efficiency of this treatment approach for arsenic removal. By comparison, all of the treatment systems listed for other mines in this table show much lower effluent arsenic concentrations than those reported for Red Dog.

When considering the impacts of Red Dog discharges to the environment and their potential impacts on local and regional water quality and aquatic life, it is imperative that all sources of releases to the aquatic environment are evaluated. This would include releases of water quality constituents in dissolved, colloidal and suspended forms. Aquatic organisms are capable of ingesting chemical constituents both from the water column and the bottom sediments. In addition, given various statements by Mr. Andrews regarding the unexpected volumes of water encountered at Red Dog, it is also reasonable to assume that data on both point source and non-point source releases should be considered in evaluating the impacts of the Red Dog project on local water quality. Mr. Andrews has failed to address these issues.

As stated above, aquatic organisms are capable of ingesting chemical constituents in both dissolved and particulate forms. As such, it is necessary to monitor and evaluate data on contaminant **loads** released into the environment, in addition to concentrations, when evaluating potential changes in the water quality and toxicity of the Red Dog area drainages. Load is the mass of a chemical constituent, such as TDS, released from or mobile at that site. Loads are calculated by multiplying the chemical constituent concentration x the stream flow or discharge volume at that site.

The surface areas of mineralized rock exposed at the site have greatly increased as a result of mining activities. In addition, the volumes of water entering the mainstem of Red Dog Creek have

increased drastically from pre-mining conditions to the present. Thus, it is critical to quantify the contaminant loads entering the local and regional surface waters in order to evaluate the total releases of potentially toxic materials into the environment. For example, the TDS loads at monitoring station 10 during pre-mining years, 1979-1983, were about 67,180 lbs / day. The TDS loads for the months during which discharges were reported in 2002 (June through October) ranged from 222,679 to 408,736 lbs. / day at station 10. By comparison, the TDS load released from the treatment plant outfall, station 001, ranged from 86,250 to 263,180 lbs. / day in 2002. The pre-mining data are taken from a summary of the 1979-82 data compiled in Scannell (Feb. 1996). The 2002 data come from the Discharge Monitoring Reports submitted by the company to EPA.

Scannell reports that median stream flow at station 10 had increased from 32 cfs during pre-mining to 182.6 cfs. in 1995.

On page 23, Mr. Andrews argues that the original water treatment plant design was based on an assumption that ground water would not need to be collected and treated. Based on the baseline water quality data presented by Dames and Moore (1983) and the exploration geochemical information which the company already possessed, that assumption appears untenable.

Testimony on the Expert Report of Michael Botz

A. Relevance to Permit.

Mr. Botz has argued that Total Cyanide in the Red Dog waters cannot be reliably quantified at low concentrations. However, the NPDES permit for site 001 became effective in July,1998 and this permit required that cyanide be monitored using the Total CN method, with permit limits of 4 µg /L and 9 µg/L, and a Compliance Evaluation Level of 9 µg / L. Cyanide data were collected by Teck Cominco according to this permit between 1998 and 2003 without having the permit changed with respect to cyanide. Teck Cominco did not challenge the permit limitations.

B. Data Quality.

Most of Mr. Botz's opinions are based on the position that the analytical techniques utilized by the two laboratories that Teck Cominco used to perform Total CN analyses between 1998 and 2002 were incapable of producing reliable, quantitative results at low concentrations. Thus, these arguments question the overall quality of the monitoring data. Mr. Botz rightly states at the top of page 7, that there is error with all analytical measurements. However, most water quality experts, myself included, would argue that the total error or uncertainty in water quality data results from a combination of numerous factors related to both *field sampling* and *laboratory analytical procedures*. In fact, at sites having chemically-complex waters, such as metal mine sites, it is generally true that the total error introduced by variability in sample collection and handling procedures is considerably greater than the error resulting from laboratory procedures. In other words, the procedures one uses to collect, handle and transport chemically-complex samples usually accounts for much more of the reporting error than do the analytical errors.

Unfortunately, Mr. Botz fails to present any discussion or analysis of the variability due to sampling error. In numerous statements, all of the Teck Cominco experts have mentioned the harsh

conditions at Red Dog site, using these as explanations for many of the lapses in past monitoring or performance. Thus, it would be reasonable to expect that they, including Mr. Botz, would have taken great pains to quantify the sources of sampling and analytical errors, using statistically-reliable approaches, with "blind" samples [samples labeled so that analysts could not identify individual replicates], *independent* round-robin studies, etc. Apparently, none of these approaches were used by Mr. Botz to reliably quantify variability due to either sampling or analytical errors.

Mr. Botz provides no evidence that the routine analytical performance of the two laboratories used by Teck Cominco for cyanide analyses were subject to *independent* round-robin scrutiny, checking their accuracy and precision on chemically-complex waters. No information is provided to indicate that these two labs were chosen because of positive performance in such independent tests using chemically complex waters.

None of the Teck Cominco experts, including Mr. Botz, present details on the actual sample collection and handling procedures used at Red Dog. As a result, we are unable to assess the variability resulting from such issues as depth-integration of samples, compositing of samples and the timing of preservation, holding times, data reporting errors, etc. Again, none of these issues were evaluated or discussed, and they routinely tend to account for greater amounts of error in reported results than do the sum of the analytical errors.

On page 20, Botz discusses a study conducted by E&E 2004 --which I have yet to be provided with-- that evaluated the variability of cyanide data collected from NPDES outfall 001, using numerous, *unnamed* laboratories, two of which were the labs that performed cyanide determinations of Red Dog analyses during the period of 1998—2002. While several labs were part of this comparative study, only the data and conclusions from the two labs employed by Teck Cominco are presented and discussed. Once again, no specific details are presented on how split sampling and sample handling were performed. Presumably, all of the effluent monitoring data discussed by Botz, including discussions in his Expert Report sections 6.0—8.0, were collected by staff or representatives of Teck Cominco. There is no discussion of any 001 site sample results that have been *collected and analyzed* by *independent parties.* Thus, the public is forced to evaluate the details of these cyanide and other analytical issues using only company-collected samples.

In section 7 of his Expert Report, Botz calculates Method Detection Limits (MDL) and Minimum Levels (ML) using the *split sample* data from the E&E 2004 study, which are, apparently, from samples collected during 2003-2004. However, he does not include or discuss the cyanide data from *all of the labs* in the E&E study. Apparently the 41 replicate samples discussed in Table 8, on which the calculated MDLs and MLs are based are actually the 31 replicates discussed previously in table 7---but this is unclear.

Botz states that, under perfect conditions, the pairs of replicate samples would all have the same CN concentrations. However, again, we are not told any details about how the replicates were collected, split and handled, on what dates and times they were collected, were they "blind" replicates, etc. Furthermore, he uses these data to calculate MDLs and MLs as though they are replicates of the same sample---*which they are not.* Based on the limited explanation given, I can only conclude that the data in tables 7 and 8 represent 31 (41?) pairs of split samples, each pair collected at a different time, and possibly on different dates.

The chemical composition of the ore and the operational efficiency of both the mine ore processing facilities and the water treatment plant all vary continuously through time. *Hence, the chemical content of effluent samples collected from discharge site 001 would also vary continuously.* Thus, the replicate samples shown in tables 7 and 8 represent 31 different samples, split into pairs, of the effluent chemical quality---*not* 31 (or 41 as listed in Table 8) replicates of effluent water with the same composition. Botz has made statistical calculations on the assumption that there is a sample population of 31 (or 41) replicates, when in fact there is only a statistical population of 2 for 31 (or 41) different samples / populations. Thus, Botz's MDL and ML calculations were performed using inappropriate approaches and data that do not come from 31 true replicate samples and therefore lead to unreliable conclusions.

It would be informative to see a statistically-correct evaluation of the E&E (2004) results using data from all of the laboratories investigated, evaluating all of the data for both WAD and Total CN analytical methods. There is no disagreement that all data are subject to error, including data from Total and WAD CN determinations. However, Botz has not demonstrated in a statistically-reliable fashion how much total error is present in the 1998 –2002 Red Dog Total CN data.

C. Analytical Interferences.

Mr. Botz argues that the presence of numerous chemical compounds can interfere with the analysis of cyanide in water samples. This is correct. In fact, some degree of analytical interference is the norm when analyzing chemically-complex waters. However, Mr. Botz presents no data reporting the presence or actual concentrations of these interfering compounds / constituents in actual Red Dog samples. In order to reliably demonstrate the interference effects of these compounds he would need to present the thiocyanate, sulfide, nitrate and nitrite concentrations, for example, in statistically-significant numbers of samples of Red Dog samples. No such data are provided.

Many of the chemical compounds listed as interferences by Mr. Botz on page 7, such as aldehydes, glucose and other sugars, and fatty acids, are not routinely reported as being present in mine waters. If their presence is an analytical concern, then their concentrations *in Red Dog samples* should have been demonstrated and quantified, along with their interference effects. No such data have been presented.

Many of the technical references on chemical interferences cited by Mr. Botz and Dr. Mudder were published many years prior to the issuance of the Red Dog NPDES permit, yet Teck Cominco did not challenge the Total CN requirements of the permit when it was issued in 1998.

On pages 9-11, Mr. Botz discusses thiocyanate as an interferant in Total Cyanide analyses using data from *prepared* solutions, not Red Dog samples. He provides no quantitative data on the routine presence of thiocyanate in Red Dog samples. Equally significant, these synthetic samples were prepared by adding 100 **mg/L** (100 parts per million) of thiocyanate to a solution containing only 250 **µg/L** (250 parts per billion) of total CN. Thus, the synthetic samples had *very high* concentrations of thiocyanate as compared to the *much lower* concentrations of the other total cyanide contents. Yet, Mr. Botz fails to provide any data to demonstrate the reasonableness of these proportions or the concentrations of thiocyanate in Red Dog samples. Nor does he demonstrate the degree of interference from thiocyanate in actual Red Dog samples.

The interference data (synthetic samples) presented by Mr. Botz show that thiocyanate may theoretically interfere in both routine Total and WAD CN determinations.

On page 11, Mr. Botz presents data on synthetic samples showing the interference effects of nitrate and nitrite. Both compounds might *theoretically* be acting as interferences at Red Dog, but as no actual Red Dog nitrite or nitrate sample concentrations are presented, this is pure speculation. It is quite rare, however, to measure significant concentrations of nitrite in mine surface waters. On the other hand, nitrate is quite common in mine effluents (often in association with toxic ammonia), resulting from both the decomposition of other mine chemicals and as a residue from the use of blasting compounds. As a minimum, these studies should have reported statistically-valid concentrations of the common nitrogen forms (i.e. nitrate, nitrite, ammonia, organic nitrogen) present in actual Red Dog waters when evaluating potential analytical interferences.

D. Toxic CN Forms

On pages 4 through 6 and other pages, Mr. Botz discusses the various forms of cyanide in natural environments. This discussion is, however, quite incomplete and misleading in several aspects. For example, it is misleading to focus on free CN as the only environmentally important and toxic form of CN---especially when there are no approved or reliable analytical methods for determining free CN at low concentrations. The goal should be to measure all of the forms of cyanide and related compounds that are known to be toxic in aquatic systems, not simply to measure free CN.

The analytical procedure referred to as Total Cyanide does not, contrary to what is implied in its name, report all of the environmentally-important forms of CN (Moran, 1998, 2000, 2001, 2002). The same is true for the weak acid dissociable (WAD) CN analytical procedure. Neither method reports thiocyanate (British Columbia, 1986). Thiocyanate and cyanate are commonly present in mine waters where metal-sulfide ores exist, such as at Red Dog, and are toxic to aquatic organisms. It is correct that both cyanate and thiocyanate are less toxic than free CN to aquatic organisms, but both forms are toxic in and of themselves. Thus, it is especially misleading to refer to thiocyanate as simply a source of analytical interference.

Both WAD and Total CN analytical methods fail to report / detect the presence of many other forms of CN or CN-related compounds likely to be present in metal mine waters. Thus, contrary to the statements made by Mr. Botz, it is much more likely that both WAD and Total CN determinations routinely under-report, rather than over-report the presence and potential toxicity of CN and related forms in mine waters.

It is also misleading to simply report that many metal-cyanide complexes are of little importance in terms of toxicity to aquatic organisms. Firstly, data on the toxicity of many of these complexes to aquatic organisms are simply lacking. Secondly, many of these complexes are themselves reported to be toxic to aquatic organisms but also release free cyanide when exposed to sunlight. Mr. Botz's expert report does not discuss these complexes.

E. Analysis of Background Water Samples

Mr. Botz fails to present any quality assurance-quality control information (QA/QC) on the performance of these laboratories, including statistically-valid evaluations of spikes, precision and accuracy, or independent round-robin performance data. These data do not necessarily represent the actual presence of cyanide compounds in the site background waters, but could equally indicate laboratory contamination. We are not informed whether any of these three labs were the same labs used by Teck Cominco for routine CN monitoring during the1998- 2002 period of interest. It is unclear whether these data were utilized in the later E&E (2004) study.

F. Cyanide Speciation Analyses.

Section 6.3 of Botz's Expert Report states that low concentrations of metal-cyanide complexes were measured in the Outfall 001 samples analyzed by Frontier Geosciences. However, the report does not discuss the criteria used to select samples for CN speciation analysis. Botz does not explain whether the Outfall 001 samples chosen for speciation were representative of the full range of Total CN concentrations, or whether only low Total CN samples were selected. Also, the range of specific metal-cyanide complexes determined by Frontier Geosciences was quite limited and neglected to include many of the dozens of other potential metal-cyanide complexes that might be expected in such mine effluents (Flynn and Haslem,1995), including iron and manganese complexes.

Section 6.3 of Botz's report fails to discuss whether potential chemical interference agents were measured in the Red Dog CN speciation samples, the extent of the interference, and the overall precision and accuracy of the procedures, together with the overall speciation sample collection and handling procedures.

Testimony on the Expert Report of Kevin Brix.

_______Note: Many of my comments made above concerning the opinions of Gene Andrews and Michael Botz are also relevant to the opinions of Kevin Brix. Among others, the comments relating to overall water quality and sediment sampling inadequacies and CN sampling and toxicity are relevant to Mr. Brix's opinions.

Teck Cominco committed violations of its NPDES permit for cadmium, total dissolved solids, cyanide, and whole effluent toxicity (WET) at the Red Dog Mine between August 1998 and May 2003.

Releases of contaminants from the Red Dog Mine caused increased loading of contaminants to the environment which likely contaminated both waters and bottom sediments. Contaminants in the bottom sediments can become redissolved under changing water chemical conditions, and be consumed by aquatic organisms, both as dissolved and particulate forms.

Teck Cominco performed inadequate studies to identify and address the environmental and human health risks to the region.

The fact that water samples comply with NPDES or other regulatory limits for total dissolved solids (TDS) content does not mean the TDS found in the water is benign or non-toxic.

Mr. Brix argues that TDS concentrations are largely benign in terms of potential toxicity to aquatic organisms and other life. However, Total Dissolved Solids (TDS) is simply a *general* measure of the chemical components dissolved in a water sample. *TDS concentrations, by themselves, tell the observer nothing about the specific chemical composition or toxicity of the water sampled.*

In order to gain a detailed understanding of the chemical components actually present in a water sample--and indirectly represented by the TDS concentration—the sample must be analyzed for a wide range of major and minor chemical components. The major ions should include, as a minimum, silica, calcium, magnesium, sodium, potassium, alkalinity, sulfate, chloride, and nitrate (Skougstad, et.al, 1979). However, when water samples are either acidic or highly alkaline, numerous minor constituents become dissolved at significant concentrations and become important components in the determination of TDS. Many of these normally minor chemical constituents may be toxic to aquatic organisms and other life. Such is the situation at the Red Dog Mine. Most of the water samples are acidic prior to treatment and are rendered highly alkaline during treatment.

According to data in Scannell (1996), treated effluents released to Red Dog Creek from NPDES site 001 during 1995 often had pH values as high as 10. Similar elevated pH levels, sometimes above 10, are reported on the site 001 DMRs for 1999—2003 and into 2004. Clearly such effluents would be toxic to many aquatic organisms strictly on the basis of elevated pH. In addition, evidence from numerous other mine sites shows that such high pH treated effluents often contain elevated concentrations of many potentially toxic minor, either in solution or as microparticles.

In order to separate and extract the desired metals from the ore, the following chemical reagents are added: methyl isobutyl carbinol, potassium ethyl xanthate, sodium ethyl ether, potassium amyl xanthate, sodium isobutyl xanthate, sodium metabisulfite, zinc sulfate, copper sulfate, sodium cyanide, sodium sulfide, lime, sodium hydroxide, organic antiscalents and flocculents (correspondence: James Kulas, Teck Cominco to Enoch Adams, Jr., Oct. 11 and 13, 2002). Tons per year of most of these reagents are used in processing at Red Dog. For example, about 155 tons per year of sodium cyanide is used, which generates numerous cyanide and related breakdown compounds (metal-cyanide complexes, cyanate, thiocyanate) as wastes. In addition, the mine utilizes large quantities of explosives (i.e. ANFO, ammonium nitrate-fuel oil, dynamite, etc.) and fuels (diesel, gasoline, kerosene), oils and lubricants, the residues of which are routed into the mine wastes and then to the treatment plant.

This chemically diverse "soup" of natural and industrial chemicals is far too toxic to be released directly into the environment, thus it is sent to the treatment plant. However, Mr. Brix makes no mention of and cites no data for most of these chemical constituents in the Red Dog water samples. Likewise, he fails to consider most of these constituents in either water or sediment samples when evaluating potential toxicity to any forms of life.

Routine monitoring of Teck Cominco's effluent and the waters impacted by Teck Cominco's discharges do not directly survey for most of these reagents. Many of these reagents or their breakdown products would likely be in the total load discharged by Teck Cominco.

The treated effluent at site 001 and numerous other non-point sources around the mine add significant volumes of TDS and other chemical constituents in both dissolved and particulate forms into the

Middle Fork Red Dog Creek. While much of the chemical load released into the drainage system is originally in dissolved form, it rapidly converts into particles which settle to the stream bottom. These particles are partly composed of metal compounds, and metal-cyanide compounds, many of which may be ingested by benthic organisms and fish, leading to toxic responses in the aquatic communities.

The fact that water meets drinking water standards for certain parameters does not necessarily mean it is safe for human or animal consumption or non-toxic to aquatic life. Mining effluents, even treated effluents that comply with all NPDES limits for specific chemicals, may still be toxic to aquatic organisms. This conclusion has often been verified by various forms of toxicity testing in both the United States and Canada. While the exact explanation is usually unclear, it is likely that the effluents contain concentrations of some chemical constituents not included in the list of monitored constituents. WET tests provide the best synoptic means of evaluating the overall toxicity of such chemically-complex effluents.

Teck Cominco has failed to collect monitoring data for numerous chemical constituents in both its effluent and ambient monitoring that are known to be toxic to aquatic life and human health if present in excessive concentrations in both sediments and water. These include, for example, antimony, arsenic, thallium, uranium and others. It seems likely that the presence of many of these undetermined chemical constituents discharged into the Red Dog surface waters could be the cause for much of the unexplained toxicity mentioned in Mr. Brix's opinions.

The mine is required by its NPDES permit to perform whole effluent toxicity tests, also known as WET tests. Under the permit, the WET tests involve the use of a species of water flea, *Ceriodaphnia dubia*, and a small fish, *Pimephales promelas*. These WET tests are used precisely because of the complexities mentioned above. That is, these organisms are exposed to various concentrations of the effluent to determine the degree to which it may be toxic. WET tests often indicate potential toxicity even though the concentrations of all chemical constituents tested in the water sample are in compliance with the NPDES limits.

The repeated failure of the mine's WET tests (Teck Cominco has reported violations to EPA of its WET permit limits in September 1998, May 1999, July 1999, August 2000 and August 2001, as well as in September 2002) indicates that the effluent is, indeed, toxic to some forms of aquatic life in the receiving water.

Testimony on the Expert Report of Joyce Tsuji.

_______Note: Many of my comments made above concerning the opinions of Gene Andrews, Michael Botz and Kevin Brix are also relevant to the opinions of Joyce Tsuji. Among others, the comments relating to overall water quality and sediment sampling inadequacies and CN sampling and toxicity are relevant to Dr. Tsuji's opinions.

Water for the drinking water system of Kivalina was drawn from the Wulik River at Station 1 into a holding tank in August 2002. One presumes that this water was then chlorinated, but that is undetermined. This water is stored as a source for use later in the year. During the summer, however, residents of Kivalina take drinking water directly from the Wulik River. As Teck Cominco did not collect samples from this storage tank until December 2002, these samples are not representative of the water

quality in the tank soon after water extraction in August, nor are they representative of drinking water taken directly from the river during the summer.

TDS, cyanide, cadmium and other chemical constituents discharged by Teck Cominco into the Middle Fork Red Dog Creek will flow downstream with the regular stream flow, entering the Main Stem Red Dog Creek, the Ikalukrok Creek, and the Wulik River, in turn. Once in the Wulik they will flow downstream to the mouth of the Wulik with the regular flow of the river.

Harms to human health, the aquatic life, and the environment caused the by discharge from the mine will be less likely and/or less severe if Teck Cominco abides by its permit requirements.

I reserve the right to modify and supplement my opinions as further information becomes available, including through deposition of defendant's experts, and to express new opinions in response to new information or to opinions expressed by defendant's experts. Additionally, I have not been given access to several of the reports and publications on which Andrews, Botz, Brix and Tsuji relied in making their expert opinions; I have been informed by plaintiffs' counsel that these documents were requested of Teck Cominco but have not been provided to plaintiffs. I reserve the right to modify and supplement my opinions once I have been provided all data and publications on which defendant's experts relied.

The fact that I have focused only on certain statements in the reports of Andrews, Botz, Brix and Tsuji does not reflect my acceptance or agreement with those statements not specifically addressed here.

My agreement with the plaintiffs specifies that I will be paid my normal hourly, litigation billing rate for non-profit organizations of $100.00 per hour. My hourly rate for trial testimony is $200.00 per hour. I have testified at trial or by deposition in the cases listed in my resume., attached.

References

British Columbia, 1986, Water Quality Criteria for Cyanide, Overview Report: Ministry of Environment, Water Management Branch, Resource Quality Section; 8pgs.

Dames & Moore, Jan. 1983, Environmental Baseline Studies, Red Dog Project. Prepared in Association with L.A. Peterson & Assoc., Stephen R. Braund & Assoc., T. J Gallagher, Edwin Hall & Assoc. Prepared for Cominco Alaska.

Flynn, C. M. and S. M. Haslem, 1995, Cyanide Chemistry—Precious Metals Processing and Waste Treatment: U. S. Bur. of Mines Information Circular 9429, 282 pg.

Moran, Robert E., 1998, Cyanide Uncertainties—Observations on the Chemistry, Toxicity, and Analysis of Cyanide in Mining-Related Waters: Mineral Policy Center Issue Paper No.1, Wash., D.C.

Moran, Robert E., 2000, Cyanide in Mining: Some Observations on the Chemistry, Toxicity and Analysis of Mining-Related Waters: *in* Proc. Central Asia Ecology—99, Lake Issyk Kul, Kyrgyzstan, June,1999.

Moran, R.E., 2001, More Cyanide Uncertainties: Lessons from the Baia Mare, Romania, Spill---Water

Quality and Politics. Mineral Policy Center Issue Paper No. 3, Wash. D.C., 15 pgs.
Moran, Robert E., 2002, De-coding Cyanide. A Submission to the European Union and the United Nations Environment Programme: Sponsored by Hellenic Mining Watch, Ecotopia, CEE Bankwatch, FOE Europe, FOE Hungary, FOE Czech Republic, Food First Information and Action Network, Minewatch UK, and Mineral Policy Center, 25 pg.

Scannell, P.W., Feb. 1996, Red Dog Use Attainability Analysis, Aquatic Life Component: Alaska Dept. of Fish & Game Technical Rept. No. 96-1.

Skougstad, M.W., M.J. Fishman, L.C. Friedman, D.E. Erdmann, and S. Duncan (editors), 1979, Methods for Determination of Inorganic Substances in Water and Fluvial Sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Chapter A1, Book 5.

Slack, J.F., J.A. Dumoulin, J.M. Schmidt, L.E. Young, C.S. Rombach, 2004a, Paleozoic Sedimentary Rocks in the Red Dog Zn-Pb-Ag District and Vicinity, Western Brooks Range, Alaska: Provenance, Deposition, and Metallogenic Significance. Economic Geology, Vol. 99, pg. 1385-1414.

Slack, J.F., K.D. Kelley, V. M. Anderson, J.L. Clark, R. A. Ayuso, 2004b, Multistage Hydrothermal Silicification and Fe-Tl-As-Sb-Ge-REE Enrichment in the Red Dog Zn-Pb-Ag District, Northern Alaska: Geochemistry, Origin, and Exploration Applications. Economic Geology, Vol. 99, pg. 1481-1508.